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by
Jac J. Sijben

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Address : Warandelaan 2, P.O. Box 90153, 5000 LE Tilburg, The Netherlands
Phone : +31 13 663050
Telex : 52426 kub nl
Telefax : +31 13 663066
E-mail : "center@htikub5.bitnet"

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Monetary Policy in a Game – Theoretic Framework

Spieltheoretische Ansätze zur Geldpolitik

By Jac J. Sijben*), Tilburg

1. Introduction

In the last decade the classical controversy about the pre-announcement of rules versus a discretionary monetary policy has been revitalized. This renaissance was linked with the rise and the further development of the rational expectations theory or new-classical economics on the one side and with its implications for the effectiveness of macroeconomic stabilization policy on the other side (Sijben, 1980). In this context empirical research with regard to the ineffectiveness-postulate (Lucas, Sargent and Wallace) was also strongly emphasized (Barro, 1977).

In the seventies the debate with regard to the ineffectiveness of economic stabilization policy did repel gradually the traditional Keynesian-monetarist controversy about the influence of monetary and fiscal policy in the sixties. However at the same time a new policy-issue came about which put the debate on monetary-policy behavior in a game-theoretic framework. This issue refers to the fact that in the course of time policy-makers will be tempted to change their original policy-strategy with regard to the inflation-unemployment trade-off. In the literature this question is known as "the time inconsistency of optimal plans" (Kydland and Prescott, 1977 and Taylor, 1985) and is closely related to the concepts of credibility and reputation of the central bank. At the end of the seventies its attention was excited when in several countries central banks were changing their policy-behaviour, accompanied by a sharp reduction in economic activity. In other words it appeared that in practice a disinflation policy was very costly, requiring large, albeit temporary, increases in unemployment. (1979–1983 in the UK and the US). This development resulted from the fact that during the seventies the public had lost its confidence in the central bank with regard to the uphold of monetary stability and workers and business had adjusted wages and prices in accordance with their inflationary expectations. In this strong inflationary environment a change of the monetary-regime, a disinflation strategy, will confront policy makers with a rise in unemployment and a slackening of economic activity. The meaning of the "time-inconsistency problem" with regard to the macro-economic stabilization policy is expressed by Taylor (1983, p. 123) as follows, "The possible time inconsistency of optimal policy is one of the most important policy issues that has emerged from research on rational expectations in macro-economics".

*) The author is Professor of Monetary Economics at Tilburg University and the Post-graduate School of Financial Economic Management, Tilburg, The Netherlands.

This essay deals with a non-technical review of the current issues in the international literature in the field of the game-theoretic approach in monetary policy. Especially the importance of credibility and reputation of policy makers with regard to the formulation and the implementation of monetary policy will be emphasized. According to this approach the interaction process between the strategic behaviour of the policy maker and the public will result in an endogenous monetary policy. The traditional view according to which the public responds to monetary impulses in a rather mechanical and predictable way will be abandoned.

Based on the stimulating articles of Kydland-Prescott on the one side and of Barro-Gordon and Backus-Driffill on the other side, in section 2 the modern game-theoretic approach in monetary policy will be presented. In this section it will be shown that in an environment with rational economic agents the choices of monetary authorities with regard to their policy behavior in a Phillips-curve analysis will be restricted essentially. This results from the fact that a discretionary monetary policy has to be abandoned, because in the long run the macroeconomic pay-off in terms of inflation and employment will be less beneficial than in case of sticking to a pre-announced monetary growth rule. This conclusion is not based on Friedman's previous well-known arguments with regard to the variable lags and the timing and uncertainty in monetary policy, but is rather based on the game-theoretic view that "economic planning is not a game against nature but, rather, a game against rational economic agents". (Kydland and Prescott, 1977, p. 473). Section 3 deals with the importance of asymmetric information between the policy maker and the public on the one hand and with the impact of the degree of independence of the central bank on the effectiveness of monetary policy on the other hand. Finally section 4 concludes with some summarizing remarks.

2. *A Game-theoretic Approach*

Credibility

Since the introduction of the rational expectations theory (Lucas, Sargent, Wallace) and the concomitant Lucas-critique in the seventies, much attention has been given to the impact of credibility of policymakers in analysing the question about rules versus discretion in monetary policy. The last few years the concepts of credibility and resoluteness of policy actions have been emphasized very strongly in considerations about the formulation and implementation of monetary policy. Fellner, who introduced this concept in macroeconomics, has pointed out that the adjustment process during the transition period to lower inflation will be longer and more costly in terms of a loss of production and employment the less credible the anti-inflation policy (Fellner, 1979 and McCallum, 1984). This concept is very crucial because the inflationary expectations of the rational public will determine ultimately the ability of policymakers, the central banks, to achieve their final objectives. In their turn these inflationary expectations are dependent on the public's assessment of the credibility of central bank behavior.

In the literature on monetary theory credibility is defined as the extent to which the rational economic agents do believe that a change in the monetary regime occurred at the moment this policy change actually took place. In this context McCallum points out, "Credibility obtains to the extent that beliefs concerning policy conform to the way

in which policy is actually being conducted and to official announcements about its conduct" (McCallum, 1984, p. 105). This means that a new monetary policy-regime will be credible as it is believed immediately, notwithstanding the fact whether this new policy involves higher or lower inflation. Subsequently it is also very important that each moment the policy is consistent with the information of the public with regard to the objectives and limitations of the central bank. Therefore a monetary policy announcement will be less credible when the public is convinced that the policy intention is incompatible with the current targets of policymakers (Cukierman, 1986).

In the course of the seventies, characterized by a high inflationary environment in the industrialized countries, central banks got increasingly convinced of the significance of maintaining the credibility of their anti-inflation policy. In this decade the rate of inflation has been increased by the rise of oil-prices and excessive wage-demands on the one side and by an expansive fiscal policy on the other side. In these circumstances the public became very sceptical about the possibilities and in particular about the willingness of central banks to maintain monetary stability. During the seventies two views have been put forward to reduce and to eliminate the accelerated rate of inflation. On the one hand an anti-inflation programme aiming at a gradual and predictable reduction of the rate of inflation (gradualism) and on the other hand a more radical programme emphasizing an immediate reduction of the rate of inflation (commitment). These policy recommendations reflect the different views with regard to the speed of wage-and-price adjustments (contracts, institutions) and the concomitant costs in terms of production and employment. The success of both programmes is crucially dependent on the degree of policy-credibility. A lack of credibility will hinder a sufficient reduction of inflationary expectations, increasing the probability of a recession. In the seventies monetary policymakers in several countries have conceded the wage- and price demands of trade unions and firms and the budget-deficits of the governments, feeding the arise and the self-generating inflationary processes. It is obvious that in such an inflationary environment the classical debate about rules versus discretion in monetary policy will be revitalized. The game-theoretic approach in monetary policy was initiated by the Lucas-critique and the concomitant interaction between the strategies of the players of the game (policymaker and the public).

The Kydland-Prescott Analysis

As is well-known from the literature the issue of the most appropriate monetary policy strategy has always been strongly emphasized in economics. After the second world war, based on Keynesian economics, it was put forward that in the framework of economic stabilization policy a discretionary policy could always replace a fixed monetary growth-rule. For it was reasoned that smart policymakers could always make use of the lack of full information about the working of the economic process (private information) in implementing monetary policy. In this context Barro notes, "there is a substantive role for monetary policy only to the extent that the monetary authority has better information than the public" (Barro, 1976, p. 26). A decade later he points out this view as follows, "Then if the policymaker was also well-meaning, there was no obvious defense for using a rule in order to bind his hands in advance" (Barro, 1985, p. 23).

This view, which still gives some room for discretionary policy, was heavily criticized in an elucidate and stimulating article by Kydland and Prescott (1977). During the

eighties their analysis had a strong influence as well on the theory of macro-economic stabilization policy as on the issue of international coordination of economic policy. The nucleus of the recent research on the game-theoretic approach in monetary policy refers to the costs of disinflation policy in terms of production and employment on the one hand and to the question how to formulate and implement this policy to minimize these costs on the other hand. Kydland and Prescott point out that a credible and steady preannounced monetary policy rule always generates a better pay-off in terms of inflation and employment than a discretionary policy, when the macroeconomic outcomes are dependent on the expectations with regard to future monetary policy (Lucas-critique). In this context the several political institutions also play a crucial role in formulating and implementing economic policy and in the ultimate course of the economic process. Alesina and Tabellini explain it as follows, "The basic motivation of the novel literature on credibility and politics is that it is not harmless to abstract from political institutions in modelling economic policy. The recent theory of economic policy views policy making as a game between the policymaker and the private agents in the economy" (Alesina and Tabellini, 1988, p. 452 and Alesina, 1987). In the last decade the game-theoretic concept of credibility also played a significant role in the context of the need for an international coordination of economic policies to correct the financial imbalances in the world economy. This results from the fact that a system of flexible exchange rates has appeared not to be able to eliminate the mutual interdependence of economic policies between countries. (Miller and Wallace, 1985 and Hamada, 1974). Moreover the game-theoretic approach is also practised in the interactions between monetary and fiscal policy (central bank versus the Treasury) (Tabellini, 1986).

The following considerations are based on two elucidate essays of Cukierman and Barro-Gordon respectively, which point out the essential characteristics of the Kydland-Prescott game-theoretic approach quite concisely (Cukierman, 1986, Barro-Gordon 1983-b and Backus-Driffill, 1985). In the basic-model macroeconomic policy is characterized as a non-repeated game (single stage or one-shot game), in which the central bank determines the actual rate of inflation (π) and the public builds-up its inflationary expectations (π^*). The game consists of the players (the policymaker and the public), the strategies and the outcomes of the players. It is obvious that the time-dimension plays a critical role in game theory. In a non-repeated game the game is played only one time. This means that no confrontations between the players have occurred nor in the past nor at present, so avoiding the influence of confrontations on actual behavior. It also implies that in this simple game strategic interactions between the players will not come about. Moreover this analysis refers to a non-cooperative game, implying that there is no precommitment about rules of the game. In this way the players are quite free to choose their optimal policy-strategy. However in a cooperative-game the possibility exists to tune the strategy-choices to each other.

The basic-model, focusing on the Phillipscurve trade-off between inflation and employment, consists of the following fundamental relations.

$$Y_F = Y_N + (\pi - \pi^*) \quad (1)$$

Y_F : actual production

Y_N : natural production

π : actual rate of inflation (rate of monetary growth)

π^* : expected rate of inflation

This equation refers to the well-known Lucas-supply function pointing out that deviations from the natural level of production (employment) are positively related to the unexpected rate of inflation. In other words expectations-errors with regard to inflation generate real effects. This view is based either on a short-run Phillipscurve according to Lucas (general versus relative prices) or on a supply-function in the context of the contract theory according to Fischer-Taylor with price and wage rigidity¹⁾ (Sijben, 1980). For simplicity it is assumed that the rate of monetary growth (m) always equals the rate of inflation (π), while the expected rate of monetary growth (m^*) determines the expected rate of inflation (π^*).

Subsequently an objective function of the central bank is assumed according to which monetary authorities attach a negative weight to inflation while they value an increase of production and employment ($Y_F > Y_N$) positively. The macro-economic outcome (U_0) of the policymaker can be described as follows:

$$U_0 = -\pi^2 + \alpha (Y_F - Y_N), \alpha > 0. \quad (2)$$

The third equation refers to the objective function of the public, emphasizing a rational public which dislikes to be fooled by the policymakers by organizing a surprise inflation ($\pi - \pi^* > 0$). In other words the public prefers a zero-surprise inflation which, according to equation (1), implies an actual rate of unemployment equal to the natural rate of unemployment. The outcome of the public (U_p) can be rendered as follows:

$$U_p = -(\pi - \pi^*)^2 \quad (3)$$

The public knows the policy behavior of the central bank and will accordingly determine the inflationary expectations (π^*) which play a crucial role in the process of wage-demands. A zero inflation and the concomitant monetary policy will be considered optimal because the public dislikes inflation. In these circumstances the actual and the expected rate of inflation will be zero ($\pi = \pi^* = 0$) and so there is no fooling of the public. This means that the level of actual production coincides with the level of natural production ($Y_F = Y_N$) (equation 1).

Based on this model monetary policy will become endogenously. This results from the fact that the policymaker is maximizing its objective function taking into account the rational behavior of the public. This implies an interaction between the policymaker and the public which, according to the game-theoretic analysis, can be described in the following way (Backus and Driffill, 1985). As was pointed out before policymakers and the public are involved in a macroeconomic non-cooperative game aimed at the fixation of a rate of inflation and an employment level.

Substituting equation (1) in (2) the following objective function of the policymaker in terms of the rate of inflation results:

$$U_0 = -\pi^2 + \alpha (\pi - \pi^*), \alpha > 0. \quad (4)$$

¹⁾ The Lucas-supply relationship can also be formulated as a variant of Friedman's natural rate of unemployment hypothesis:

$\pi - \pi^* = \lambda(U_N - U_F)$, $\lambda > 0$. U_N and U_F refer to the natural and the actual rate of unemployment respectively. In the course of time the natural rate of unemployment can rise because of market disturbances especially with regard to imperfections on the labour market.

According to the Backus-Driffill analysis (1985), the factor α represents the policy-preference or the weights policymakers attach in their objective function to inflation and employment. It is assumed that α has a numerical value of 2. A higher numerical value of the parameter α represents a higher priority given to an elimination of unemployment and a stimulation of economic activity above monetary stability.

It is assumed that monetary authorities in formulating their policy know the public's expected rate of inflation. This means that the results of the decisions of policymakers are crucially dependent on the numerical values of the inflationary expectations of the public (π^*). Owing to the fact that there exist two inflationary or monetary regimes ($\pi = 0$ and $\pi = 1$) and two values with regard to inflationary expectations of the public ($\pi^* = 0$ and $\pi^* = 1$), each player of the game has four possible outcomes. These pay-offs will be deduced with the aid of a simple numerical example.

If the monetary authorities fix a zero rate of inflation, implementing a policy of monetary stability, then the following macroeconomic pay-offs will result (Table 1). If in these circumstances the public expects a zero rate of inflation ($\pi^* = 0$) the final outcome will also be equal to zero. This monetary policy strategy prevents inflation and does not involve a real effect (production). However if the public takes into account an expected rate of inflation equal to 1 ($\pi^* = 1$), the policymaker's outcome will be equal to -2 because of the working of the negative Lucas' supply-effect. Although there is no inflation, the real effect will be negative with a contraction in economic activity because of a negative surprise inflation. However if the policymaker chooses an inflationary policy ($\pi = 1$), while the public expects a zero rate of inflation ($\pi^* = 0$), then owing to the positive Lucas' supply-effect the policymaker's outcome will be equal to 1. In these circumstances inflation results but also a positive real effect in terms of an increase in production and employment. If in this policy regime the expected rate of inflation is also equal to 1 ($\pi^* = 1$) then the policymaker's outcome will be equal to -1 . There is no real effect and only inflation results. The surprise-effect with regard to production and employment does not arise, but only the negative inflation effect will be obtained.

Based on this simple numerical example it appears from the policymaker's view that an inflationary policy is more advantageous than a policy of monetary stability, notwithstanding the inflationary expectations of the public. The macroeconomic outcome of the inflationary-strategy of the policymaker (1, -1) is always better than the zero rate inflationary-strategy (0, -2).

The ultimate results of the policymaker's strategies characterized by alternative values of the chosen monetary regime and alternative values of the expected rate of inflation of the public can be summarized in the following matrix.

Table 1: Policymaker's Outcomes

Monetary regime (π)	Inflationary expectations (π^*)	
	$\pi^* = 0$	$\pi^* = 1$
$\pi = 0$	0	-2
$\pi = 1$	1	-1

Subsequently public's behavior has to be analyzed. As was already put forward, it is assumed that the public is always trying to prevent to be fooled by the policymaker. In other words rational economic agents attempt to avoid a surprise inflation (equation 3).

This means that the public does not agree with a real wage rate that deviates from its equilibrium level, featured by an actual level of production that equals the natural level ($Y_F = Y_N$). In determining their strategy it is assumed that economic agents know the actual rate of inflation (π). Based on the experience from the past the public knows the policymaker's priority of production and employment above monetary stability (anti-inflation policy). Therefore economic agents assume that the strategy of cheating with a concomitant surprise inflation will always be followed ($\pi = 1$). For this inflationary policy, as was mentioned before, gives the best outcome for the policymaker. This information leads to an expected positive rate of inflation by the public ($\pi^* = 1$). The ultimate result of this public behavior for the policymaker's outcome is equal to -1 (see Table 1) and according to equation (3) equal to zero for the public (see Table 2).

The ultimate outcomes of the public, given the choice-strategies of the policymaker, can be rendered as follows.

Table 2: Outcomes of the Public

Monetary regime (π)	Inflationary expectations (π^*)	
	$\pi^* = 0$	$\pi^* = 1$
$\pi = 0$	0	-1
$\pi = 1$	-1	0

Actual policy	Expectations of the public	
	zero-inflation	positive inflation
zero-inflation (pre-commitment)	Pareto-equilibrium $Y_F = Y_N$ $\pi = \pi^* = 0$	Time-inconsistency $Y_F < Y_N$ $\pi < \pi^*$
positive inflation	Time-inconsistency (cheating) $Y_F > Y_N$ $\pi > \pi^*$	Time-consistency (Nash-equilibrium) $Y_F = Y_N$ $\pi = \pi^* > 0$

Based on the foregoing considerations it appears that in the final (rational) equilibrium, characterized by a non-cooperative game with full information of the public and the policymaker, inflation always occurs. This results from the fact that based on the fixed inflationary expectations of the public, policymakers will always be tempted to cheat the public by organizing a surprise inflation aimed at increasing production and employment. However from a monetary policy view this outcome is not satisfactory. For in these circumstances an equilibrium situation occurs ($Y_F = Y_N$) with an inflationary-bias ($\pi = \pi^* = 1$), a so-called Nash-equilibrium, which is inferior to a Pareto-optimal-equilibrium, with a zero rate of inflation ($\pi = \pi^* = 0$). This Nash-equilibrium will be obtained in a non-cooperative game (no pre-commitment), in

which each player's strategy is optimal given the other's strategy. The hierarchy of the players is equal. The Nash-equilibrium is the only sustainable equilibrium that will arise when the policymaker has changed his original optimal plan and there is no room left for a surprise inflation²).

The "Time Inconsistency" Problem

In the foregoing sub-section it was put forward that a monetary policy which does not take into account the reactions and expectations of the public with regard to future monetary policy will generate a worse result than a policy based on fixed rules. In this way the question of "time inconsistency" in monetary policy came about, which can be explained as follows.

The temptation of policymakers to cheat the public and to take advantage of a change in their strategy is always existent, notwithstanding the numerical values of the inflationary expectations of the public. However because of the fact that the public has learned from experience the incentive structure of the policymaker with regard to production and employment, rational agents will not err systematically and will expect a positive rate of inflation ($\pi^* > 0$). In other words when the public has got to know the policymaker's strategy, the authorities can not use the tactic of organizing a surprise inflation systematically to stimulate economic activity. It may be obvious that this game theoretic view links up with Friedman's fixed monetary growth rule as well as with the policy implications of the rational expectations theory. The behavior of the public, characterized by anticipating the policymaker's preference, will stimulate authorities to implement actually an inflationary policy to maintain production and employment on the natural level. Ultimately a vertical Phillipscurve results on the natural level of unemployment. For if in these circumstances policymakers do not accomodate the expectations of the public a negative surprise inflation ($\pi < \pi^*$) with a concomitant contraction in economic activity will occur which is considered as a negative macro-economic outcome (see Table 1).

This monetary policy strategy (inflation-scenario) and the concomitant public behavior will generate the same level of employment ($Y_F = Y_N$) as would be the case with a monetary growth rule (zero-inflation scenario). However the actual rate of inflation will be higher implying a poorer macroeconomic result. For as was pointed out in the previous section the outcome $\pi = \pi^* = 1$ (Nash-equilibrium) is inferior to the outcome $\pi = \pi^* = 0$ (Pareto-equilibrium). In this context Kydland and Prescott (1977, p. 474-475) remark, "... the resulting policy was consistent but suboptimal. It was consistent in the sense that at each point in time the policy selected was best, given the current situation", and further on, "Doing what is best, given the current situation, results in an excessive level of inflation, but unemployment is no lower than it would be if inflation (possibly deflation or price stability) were at the social optimal rate".

The dilemma described by Kydland and Prescott that the optimal monetary policy strategy (zero-inflation) is time-inconsistent, while the time-consistent inflationary

²) In the literature on game theory a so-called Stackelberg-equilibrium refers to a non-cooperative game with a certain hierarchy in the structure, in which one of the players, the leader, takes the initiative and the others follow. If there is no monetary-policy rule (precommitment), also in this game the leader will always be stimulated to cheat the other players by changing the initial policy strategy to benefit from higher production and employment. Ultimately the leader will loose his dominant position and a Nash-equilibrium will arise.

policy (discretion) is sub-optimal has strongly stimulated further research in the field of policy-credibility. The issue of credibility and the concomitant problem of "time-inconsistency" can be formulated as follows. Before the public has made its choice with regard to inflationary expectations, a partial optimal monetary policy strategy will elicit a reaction from the public. This implies ex-post that the reaction on this initial optimal policy may be quite different from the reaction the policymaker was expecting. In other words in this way the policymaker will be confronted with quite another environment, because the public need not react in such a mechanical way as was assumed in the traditional macroeconomic models (Lucas-critique). This means that in this new situation policymakers will be stimulated to change their original optimal strategy and so renege on the initial plan, introducing the policy-credibility problem. In this context Persson points out (1988, p. 520) "Present some imperfection which makes the ex-ante optimal policy a 2nd best rather than a 1st best outcome, there is an ex-post incentive to deviations from the ex-ante policy", and further on "Therefore those policies that would be optimal if binding commitments could be made, face a credibility problem because of the incentive for ex-post deviations. Forward-looking rational agents only believe a policy announcement that will be optimal to carry out ex-post".

In other words the temptation of policymakers to drive the economy in the direction of the "first best" solution will ultimately drive the equilibrium from the "second best" to the "third best" solution because of the interaction process between the policymaker and the public. In economic literature this development is known as the "time-inconsistency" problem³). The concept of "time-inconsistency" refers to the temptation of policymakers to deviate from their original plan when they expect that rational economic agents will take into account this policy in their behavior. Maintaining policy credibility in the sense of ex-post optimality or time-consistent behavior of policymakers means an additional constraint to the policy problems confronting central banks. This implies that in each period policymakers have to determine their optimal strategy based on the inflationary expectations and decision rules of the public. In this way policy will be endogenous.

Barro and Gordon point out that in the ultimate rational equilibrium situation the monetary authorities can choose any desired rate of inflation. However if the credibility of policymakers can be guaranteed beforehand, for example by way of the introduction of a monetary policy rule (precommitment) binding the central banks in their policy behavior, the optimal solution (zero-inflation scenario) can be achieved. For in case of an absence of such an institution or of issuing a credibility-guarantee by the central bank a positive rate of inflation and a sub-optimal solution will result (Nash- or discretionary equilibrium).

Therefore Kydland and Prescott emphasize the significance of fixed rules in monetary policy which signal credibility of policymakers. This preference for rules above discretion in monetary policy and its concomitant "inflationary bias" is essentially based on the fact that the economic system cannot be characterized as a "black-box" with a given dynamic structure. This means that the current decisions of economic

³) See, Chari, 1988, p. 18, where he notes, "... To re-evaluate the policymakers calculate the optimal policies in precisely the same way they had done at the original date. If the optimal policies chosen at the future date coincide with the original plan, the policymakers will stick to that plan, and the policy regime is "time consistent". If however, the policymakers want to renege on the original plan, the policies of the regime are "time inconsistent".

agents are conditioned by their future expectations. Therefore when monetary authorities in formulating their optimal monetary policy ignore the rational behavior of the public, afterwards it will appear that the original policy has to be changed.

It is obvious that a monetary policy behavior characterized by cheating the public is not time-consistent and will deteriorate policymaker's credibility and increase the uncertainty in the economy. However a policy behavior which is time-consistent will be credible and predictable giving a real contribution to an elimination of inflation. The message of Kydland and Prescott is pointed out by McCallum in the following way, "... Thus the surprise magnitude is zero on the average, over any large number of periods, even though the monetary authority views it as controllable in each period. The discretionary outcome, it is clear, features more inflation but the same amount of surprise inflation (on the average) as under a rule. Accordingly to this model, then, a discretionary mode of policy behavior by the monetary authority leads to consequences that are unambiguously poorer than would obtain (for the same economy and the same objectives) under rule-like behavior". (McCallum, 1984, p. 114). The most important feature of a policy-rule refers to the fact that in this way future monetary policy behavior is clearly fixed and a discretionary policy with its relatively sub-optimal macroeconomic outcome can be avoided. For assuming a fluctuating monetary regime, each period the monetary authority will be confronted with the inflation-unemployment trade-off and will act accordingly. However because of the fact that the public knows the policymaker's preference for production and employment above price stability, a systematic surprise inflation cannot occur. Based on the information about policy behavior the rational economic agents will adjust their inflationary expectations to eliminate a consistent pattern of surprise inflation. A discretionary policy behavior featured by erratic changes in the monetary regime does not offer the public a guarantee concerning the future behavior of monetary authorities. Therefore an institutional change (an independent central bank) or a monetary contract between the policymaker and the public with regard to policy behavior (price- or money supply-rule) will be necessary to prevent potential ex-post "surprises" and the concomitant discretionary outcomes and to re-establish credibility. If such a restructuring of the institutions or the introduction of a formal rule is difficult or impossible to realize, then the question comes about whether it may be possible to find a more informal discipline-mechanism that can replace a precommitment or a binding contract. In these circumstances it might be possible that building up a reputation by policymakers and the concomitant reputational forces can give a solution. For a loss of credibility, as will be described further on, will imply substantial macroeconomic costs and will be punished by the public.

Shortly the foregoing discussions can be summarized in the following scheme.

In the eighties the game theoretic approach, introduced by Kydland and Prescott, has stimulated further research in the field of the "time-inconsistency problem" in monetary policy. In this context the building up of a reputation by central banks and the significance of asymmetric information is emphasized. This means that the public needs sufficient information to get to know the true identity of the policymaker (preference: inflation or employment). When the policymaker has obtained the reputation to be a "strong" policymaker giving no room for inflationary processes, the public knows the identity and can determine its inflationary expectations in a rather simple way. However as far as the policymakers have the disposal of private information (asymmetric information), the scope for organizing a surprise inflation will be increased.

3. *Asymmetric Information*

Reputational Forces

In the foregoing section it was assumed that policymakers and the public have the disposal of the same information-set. In practice, however, this is mostly not the case so that a situation of asymmetric information exists. This means that the public does not know which kind of policymaker will be the opponent in the game and the policymaker in his turn does not know public's behavior with regard to inflationary expectations and the concomitant wage-demands. For a new monetary authority may have quite another preference with regard to the macroeconomic trade-off between inflation and employment than its predecessor. This involves uncertainty and imperfect information with the public altering the macroeconomic outcome consequent on a change in the monetary-regime. Moreover the Kydland-Prescott' analysis assumes a one-shot game, while in practice the central bank has a time-horizon including several periods. This last situation refers to a repeated game or a so-called supergame in which the strategic behavior of the player is dependent on the behavior of the other player in the past. This means that in their actual decision making all players have to take into account the future consequences of the current decisions. In this way during such a repeated game a periodic optimisation is not possible because of the fact that in choosing the policy-strategy the memory and the experiences of the players play an essential role.

Backus and Driffill have shown the consequences with regard to the macroeconomic outcomes of a repeated game (Backus and Driffill, 1985 a-b and Michener, 1989). These authors assume a model with a "weak" and a "strong" policymaker. The reasoning goes as follows. The public does not know the type of policymaker and has to gather information about its identity. If the monetary authority is "weak" the macroeconomic outcomes in Table 1 will result. In that case the policymaker has always a strong incentive to organize an inflationary shock to obtain the short-term benefits in terms of production and employment. However if the monetary authority is "strong" and independent, giving no room for discretionary actions, then a zero rate of inflation will always be preferred. Private agents know that the policymaker may be either of these types but they are ignorant of which type they are actually facing. Under such circumstances there is an incentive for the "weak" policymaker to masquerade as a "strong" policymaker aiming at a downward adjustment of inflationary expectations by the public.

The following assumption with regard to public behavior can be made. In the beginning the public assumes that the policymaker is "strong" and therefore will follow an anti-inflationary policy. However the public is uncertain and does not know whether this anti-inflationary policy will actually be implemented or the strategy will be aimed at manipulating the inflationary expectations. On the contrary "weak" policymakers will always be tempted (possibly under political pressure) to inflate to generate the desired real effects in the short run. Because they intend to maximize the objective function (social welfare function) over several periods, initially they try to masquerade as a "strong" policymaker to eliminate or to prevent a rekindling of inflationary expectations. For in a world of rational expectations to obtain credibility with regard to the expected monetary policy changes will be rewarded or, as Taylor (1982, p. 81) points out, "directly reduce the costs of disinflation by changing inflationary expectations". In this way an inflationary expectations-effect results through policy-

credibility. This means that during a certain period the "weak" policymaker will be prepared to sacrifice the short-term benefits of a surprise inflation (investment in credibility) to build up a long-run reputation. In other words a "stock" of reputation will be built up, which can be used in the future if possibly the policymaker wants to give priority to a stimulation of economic activity. In these circumstances in their ex-post decisions policymakers will be faced with a so-called reputational trade-off (Persson, 1988). The higher the priority given to a building up of reputation, the greater the sacrifice in terms of a loss of real effects in the short run and vice versa. The public is watching monetary authorities continuously and wants to find out whether or not they stick to their initial anti-inflationary intentions. Economic agents try to unmask the policymaker to determine its true identity.

During this learning-process the public will gradually revise the belief that the policymaker is "strong" dependent on the actual pace of inflation. This degree of adjustment can be considered as a measure of policy-credibility. In this context credibility and the concomitant build up of a reputation can be understood as time-dependent state variables.

As long as monetary authorities are able to eliminate inflation and so stick to their initial intentions, the public will update the belief that the policymaker is "strong" increasing its reputation. If however at some time the policymaker appears to be "weak" by accepting inflation and implementing a discretionary policy, the public will punish this strategy-change immediately. This implies that the reputation will be lost directly revealing the true identity of the policymaker. This view is also pointed out by the president of the Dutch central bank, as he states, "A high rate of inflation will be incorporated in the minds and expectations of the public and eliminating these expectations costs time. Therefore the elimination of an existent inflationary process is difficult and more costly than an avoidance of inflation" (Duisenberg, 1989, p. 19).

If there is a final time-horizon and full information the reputational-mechanism can not occur. For in a finite horizon game the policy maker will always raise inflation in the final period having no incentive to invest further in building up a reputation. However rational economic agents do understand this strategy and will raise their inflationary expectations accordingly. Subsequently this reaction motivates the authorities to organize a surprise inflation in the penultimate period. But inflationary expectations will be raised in this period as well preventing the arise of real effects. In this situation the game unravels backwards ultimately resulting in a discretionary or single stage Nash-equilibrium in all periods. This view comes from the theory of industrial organization and is known as the so-called "chain store paradox" (Blackburn and Christensen, 1989). This implies that the working of the reputation-effect will only occur in a repeated game when there exists asymmetric information between the policymaker and the public.

A game theoretic analysis about the working of the reputational mechanism has been put forward by Kreps and Wilson in the field of industrial organization and imperfect competition. It deals with the question about whether or not entry occurs in a monopolistic market and in this context these authors talk about a "sequential equilibrium". It refers to a "subgame perfection" in a repeated game which ensures that the Nash-equilibrium condition in the Kydland-Prescott sense is satisfied in every stage of the game. This situation has the property that the optimal strategy for each player is his equilibrium strategy, regardless of the previous strategy-choices of the other players. In this context Kreps and Wilson remark, "So each player will be willing to carry out its

strategy at every point in the game, if ever it is called upon to do so" (Kreps and Wilson, 1982, p. 257). Essentially it deals with an interaction process in a repeated game between the strategic behavior of policymakers and a dynamic Bayesian learning-process of the public. It is obvious that such a process will arise when in the course of time new policymakers come in. In these circumstances the public is trying to find out and to learn the new policy-regime and to account for in its current decisions. During such a learning-period, indicated by Taylor as a "transition to rational expectations", the meaning of reputation of policymakers comes about very sharply. In a very early stage a new policymaker can build up credibility and reputation by clearly revealing its anti-inflationary policy by organizing a restrictive monetary policy and even by accepting a contraction of economic activity.

The Backus-Driffill⁴ analysis is restricted in that sense that the policymaker will be identified by the public either as a "weak" or as a "strong" policymaker. Therefore when reputation has disappeared it can not be build up again. This is a very strong assumption. For if policymakers have revealed a bad behavior in the past it does not mean that this will always be the case in the future. After the strong inflationary development in the seventies monetary authorities in the United States as well as in other industrialized countries have been able to change their policies and to reduce the actual inflation and the inflationary expectations. In this context it is interesting to note that the German central bank, which is a very independent monetary authority, has always pointed out very clearly its preference for monetary stability and has been successful in maintaining inflation and inflationary expectations on a relatively low level. In this way the Bundesbank has generated credibility on international financial markets and has build up the reputation of a "strong" policymaker and a stable monetary anchor in the financial world⁴).

The Reputational Equilibrium

In the novel literature on game-theory it is put forward how building up a reputation through the implementation of a pre-announced anti-inflationary policy is a possibility to reduce the social costs (the loss of employment) connected with the elimination of inflation. In this context Persson remarks, "Reputation may thus, fully or partly, substitute for formal precommitments, and lower or eliminate the costs of the credibility problem" (Persson, 1988, p. 522). This issue has been investigated in a repeated game by Barro and Gordon. In their analysis monetary authorities will build up a reputation which to a certain extent can generate the same credibility-effects as an institutionally fixed monetary policy-rule. In this way the inferior macroeconomic outcomes of a discretionary policy as described before can be improved or even avoided. The new issue in the Barro-Gordon analysis refers to the development of a reputational-mechanism, which can prevent the extreme options of a formal precommitment of a zero inflation-rule on the one hand and the discretionary outcome (inflation without real effects) on the other hand. Their analysis does not deal with an

⁴ In the game theoretic literature *Vickers* (1986) points out the meaning of a signalling-effect. This refers to the fact that in the beginning of the game the "strong" policymaker will choose such a low rate of inflation (even a recession) that the "weak" policymaker (a high-inflation type) will be deterred to masquerade him. This means that just from the beginning a clear signal will be given to the public about the true identity of the policymaker faced with during the game. It also implies that in this way the process of unmasking the "weak" policymaker can be avoided.

elaboration of the theoretical issues mentioned before, but with the introduction of the working of the reputation-effect, which supports the realisation of a rule-equilibrium (zero-inflation) as well as mitigates the incentive to cheat the public. The Barro-Gordon contribution to the time-inconsistency problem in monetary policy refers to the introduction of a reputational strategy. This strategy makes it possible to regain partially the loss of credibility caused by discretionary actions. This so-called trigger-mechanism describes how private sector inflationary expectations are revised in a rational way in response to the observed course of the actual inflationary process. In this way a connection will arise between the actual strategy-choice of policymakers with regard to employment and inflation on the one side and the concomitant inflationary expectations of the public on the other side. In building up a reputation central banks can avoid the inferior, sub-optimal, macroeconomic Nash-solution of a (consistent) discretionary policy.

The potential loss of reputation will enforce the policymaker in an informal way to stick to the pre-announced monetary policy regime and secure a lower future average rate of inflation. The working of the reputational mechanism will mitigate the incentive to cheat the public, as was mentioned in the Kydland-Prescott analysis, and in any way will reduce the degree of non-cooperative discretionary actions. Barro and Gordon clearly point out that in case temptation (the incentive to organize a surprise inflation with its concomitant short-run real effects) is equal to the enforcement (the avoidance of a loss of reputation), the policymaker will stick to the pre-announced policy regime. However if this is not the case priority will be given to cheating the public with a concomitant loss of reputation and inferior macroeconomic outcomes in the future. In this way policymakers will be faced with quite a new trade-off, namely cheating the public with real benefits in the short run versus a loss of reputation in the long run. For based on the game theoretic view cheating today implies higher inflationary expectations tomorrow.

Barro and Gordon were stimulated to look for a more informal mechanism which could avoid or improve the sub-optimal Nash-solution. They put forward that in a monetary environment characterized by symmetric information the authorities must be deterred from cheating the public. The basic reasoning of the reputational-strategy mentioned before refers to the following. The public has to fix the inflationary expectations in such a way that the policymakers will be restrained to choose a discretionary policy or a surprise inflation. In other words the concomitant potential loss of reputation has to enforce the authorities to be reluctant to cheat the public. In this context Barro points out, "Generally, a credible rule comes with some enforcement power that at least balances the temptation to cheat. We consider here only the enforcement that arises from the potential loss of reputation" (Barro, 1983 a). The working of the reputational-mechanism can be described as follows. Assume the central bank announces a rate of inflation which is lower than the inflation rate according to a discretionary policy. In these circumstances the public is watching the central bank with regard to its actual behavior and will fix the inflationary expectations in the following way. If in the previous period the actual rate of inflation was in accordance with the current inflationary expectations, the public will believe the policymaker and will maintain this expected rate of inflation in the next period. This means that the policymaker will keep its reputation of being a "strong" policymaker. However if in the last period the public has been faced with a surprise inflation, then the rational economic agents hold the view that this discretionary policy will be continued. In other words when authorities were cheating the public this policy behavior will be punished

in the next period by a loss of reputation. So the public can not be fooled systematically. This implies that the policymaker has to pay for the short-term benefits of cheating in the previous period at a price equal to a loss of reputation in the future. Then in subsequent periods a non-cooperative game will arise with a sub-optimal Nash-equilibrium. Barro and Gordon also explain that in these circumstances the public behavior of still sticking to a zero-inflation rule must be considered as irrational. For it is assumed that the public knows the policymaker's objective function. Therefore the incentive to cheat is always greater than the potential loss of reputation, making it impossible to enforce the ideal rule of zero-inflation.

The monetary authority will maximize its objective function explicitly taking into account the rational behavior of the public. In considering whether to organize a surprise inflation today with its concomitant short-run real effects or not the following trade-off results. The policymaker compares the current macroeconomic outcome resulting from a surprise inflation of the public ($\pi > \pi^*$) with the outcome generated by the inflation rate which is in accordance with the expected rate of inflation ($\pi = \pi^*$). In this comparison attention is paid to the present value of the macroeconomic costs in the next period which emerge from the fact that the cheated-public will adjust its inflationary expectations upwards eliminating the initial real effects. As was pointed out before the public assumes that the policymaker will continue its discretionary actions ($\pi > \pi^*$). As long as the present value of these costs (deterrent-effect) are greater than the short-term benefits in terms of an improvement of employment (temptation-effect), the policymaker will change the monetary regime and will choose a lower rate of inflation than is in accordance with a discretionary policy.

Based on these two monetary policy options Barro and Gordon deduce the lowest but credible rate of inflation. This rate is higher than the zero-rate of inflation according to a precommitment rule on the one side but is lower than the rate of inflation which emerges from a discretionary policy on the other side. In this context the authors point out, "We look here for the best enforceable rule – that is, the one that minimizes expected costs, subject to the constraint that the enforcement be at least as good as the temptation" (Barro and Gordon, 1983 a, p. 110. In this way the concomitant rate of monetary growth (rate of inflation) is a weighted average of the zero-inflation (precommitment) and the rate of inflation that results from discretionary monetary actions. This weighted rate of inflation is also dependent on the policymaker's discount rate, which reflects that the future macroeconomic outcome is related to the current policy actions. A high discount rate implies that a relatively high weight is attached to a stimulation of economic activity involving a higher rate of inflation. In these circumstances the role of the reputational-mechanism is weakened and a discretionary policy becomes more credible. However if the rate of discount is lower the precommitment rule will be more credible and the working of the reputational-mechanism will be stronger. Such a rule of behavior with regard to monetary policy will be enforceable due to the reputation-effect and will stimulate the policymaker to a more cooperative behavior. The policymaker will stick to this eclectic-rule of behavior when the costs in the next period are at least equal to the benefits in the previous period. When this mechanism of deterrence or of reputation-loss once has been started, the aimed goal will be realized actually. For the public is believing that the policymaker will pursue and realize this weighted rate of inflation. This means that with the absence of a precommitment rule with an optimal zero-inflation, a second-best solution with a more credible (low) rate of inflation can be obtained by incorporating a reputational-mechanism. In this way a reputational equilibrium results increasing the credibility of

the central bank. Barro and Gordon come to the conclusion that in these circumstances of a reputational-equilibrium the monetary authority announces a so-called "mid-value" of the rate of inflation which on the one hand is lower than its discretionary value and which on the other hand is positive. In this context they remark, "Whether the reputational equilibrium will arise depends on the policymaker's weighing of the benefits from the two possible modes of behavior" (Barro and Gordon, 1983, p. 604-605).

The authors are also looking for an enforceable rule in a situation characterized by asymmetric information, whereby the public does not know the priority and the discount rate of the policymaker. They also show that with asymmetric information this rule is a weighted average of the ideal (zero-inflation) rule and the inflationary outcome connected with a discretionary policy. However in these circumstances the actual rate of inflation changes with alterations in the priority and in the discount rate. This implies that a higher priority given to employment and a higher rate of discount will be accompanied by a higher unexpected rate of inflation. Conversely, policymakers will emphasize credibility and will invest in reputation. In this context they point out, "Conversely, the policymaker 'bites the bullet' - that is, creates negative inflation shocks" (Barro and Gordon, 1983 a, p. 118). In this way some scope will be built up for a future surprise inflation when at some time higher priority may be given to a stimulation of economic activity.

Taylor is criticizing this view and has some doubts about the meaning of the reputational-mechanism in a so-called positive theory of inflation. He remarks, "The fact that a suboptimally high inflation rate is the only credible policy has been offered by Barro and Gordon as a reason why we have experienced high inflation rates in recent years. To some extent the introduction of reputation-effects into the time inconsistency model makes it less attractive as a positive theory of inflationary policy: the larger are the reputation effects (for example the longer they last) the closer is the equilibrium inflation rate to zero" and further on, "In other well-recognized time inconsistency situations, society seems to have found ways to institute the optimal (cooperative) policy" (Taylor, 1983, p. 125).

Subsequently Canzoneri points out that in the Barro-Gordon reputational equilibrium the rate of inflation will be constant. According to him this is a rather odd conclusion because in practice it can be observed that in the course of time the rate of inflation as well as the rate of monetary growth are altering substantially. He remarks, "The first weakness is that the Barro-Gordon solution is, like Rogoff's too stable. If taken literally, it implies that one should never expect to see reversions to inflationary periods" (Canzoneri, 1985, p. 1064 and Rogoff, 1985). Moreover he states that the working of the reputational-mechanism is crucially dependent on the assumed punishment-strategy (loss of reputation) by the public. Therefore the monetary policy game with an infinite horizon is characterized by several Nash-equilibria, but there is no mechanism available explaining which choice will have to be made (Backus and Driffill, 1985).

Cukierman and Meltzer (1986) have further elaborated the role of asymmetric information in the context of the rules versus discretion debate. They emphasize the influence of stochastic exogenous shocks which may give an informational advantage to one of the players. Shortly their view refers to the following. In the course of time the marginal preference of policymakers with regard to inflation and employment can change substantially through unexpected events. In this way the public will be faced with policy-uncertainty. Based on observed changes in the rate of monetary growth

private agents cannot deduce immediately which part of these changes refers to a more structural change in the policy regime and which part has to be ascribed to the imprecision with regard to controlling the money supply. In their analysis policy-credibility is no (time dependent) state-variable, but will be determined by the speed with which private agents realize that a shift in the policymaker's preferences has taken place. This learning-process will be shortened and credibility will be higher the greater the precision of monetary control and vice versa.

In case of a precise monetary control some periods of monetary contraction will be sufficient to convince the public that the rate of monetary growth will be reduced permanently and that the policy-regime has been changed. Therefore inflationary expectations will be revised downwards very soon. In this context the authors point out, "In this case a "cold turkey" disinflationary policy is preferable to "gradualism" since a larger decrease in monetary expansion generates credibility relatively quick" (Cukierman and Meltzer, 1986, p. 1121). However if the precision of monetary control is very low, the public will be uncertain and unable to decide about a possible policy-shift based on the observed money supply figures. In these circumstances the obtainment of credibility with regard to a disinflationary policy takes a long time and the social costs in terms of unemployment will be higher proportionally. Then a policy of gradualism has to be preferred, enabling the public to adjust its expectations gradually with lower social costs. Subsequently the authors point out that under certain circumstances policymakers will be motivated to aim at a certain amount of ambiguity and secrecy in monetary policy, increasing asymmetric information. This means that policymakers may use the precision of monetary control as a policy instrument to cheat the public and to regain some scope for stabilisation policy.

4. Summarizing Conclusions

In the preceding sections a broad, non-technical, survey has been presented of the novel game-theoretic view with regard to the classical debate about rules versus discretion in monetary policy. In the traditional theory about macroeconomic stabilization policy it was customary to assume that policy-behavior of the central bank was exogenously given. This also implied that the structure of the economic model would not change and the public would react to certain policy actions in a predictable and rather mechanical way to achieve a desired course of economic activity. In other words economic policy-making was considered as a "game against nature". However in the recent theoretical considerations with regard to central bank behavior, stimulated by the Lucas-critique, attention is explicitly given to the role of the incentives, the constraints and the information of both policymakers and the rational public with regard to the ultimate macroeconomic outcomes of monetary policy. In the game theoretic approach the formulation of monetary policy has become less easy because the model is characterized by a strategic game, confronting the central bank with rational private agents. This new approach, which has also been applied in other fields of economics, points out that the interaction process between the behavior of the central bank and the public will ultimately result in an "inflationary bias", i.e. a sub-optimal macroeconomic outcome (Nash-equilibrium). In this way the "time-inconsistency" problem and the related policy-credibility comes about. This problem essentially refers to the fact that in the course of time, due to the reaction of the public, policymakers will be tempted to change their original optimal policy-strategy with

regard to the inflation-unemployment trade-off. There always exists an incentive of policymakers to cheat the public by organizing an inflationary-shock, aimed at obtaining short-run benefits in terms of an improvement of production and employment. If the ultimate outcome of monetary policy is also dependent on public behavior, the policymaker's ability to change its original plan has two consequences. Primarily if the public knows that the policymaker might change its original intentions (incentive to cheat), it will act in the decision-making process as if the policymaker is actually implementing the policy shift. Then this information will face the policymaker with a difficult choice at the moment the new policy has to be implemented. Either the original plan will be changed, given the new economic environment, (time-inconsistency) or the policymaker is giving priority to the long-run benefits in terms of credibility and reputation and will stick to the original optimal plan. Therefore the optimal policy might become time-inconsistent, resulting in a loss of credibility and reputation. In section 3 the asymmetric information in the game theoretic framework is emphasized, dealing with the crucial concepts of credibility and reputation of the policymaker.

Due to the experiences with severe inflations in the seventies, recent economic research on the rules versus discretion debate is strongly emphasizing the role of policy-credibility and reputation of central banks to prevent a rekindling of inflation. This development has revitalized the old controversy about rules in monetary policy versus discretionary monetary actions. The "time-inconsistency" problem is re-emphasizing very clearly that the concepts of uncertainty, information and expectations play a significant role in the interaction process between the policymaker and the public and therefore are very crucial for the ultimate course of the economic process. The empirical research in the field of credibility and reputation with regard to monetary policy is still in its infancy and many problems have to be resolved. (Baxter, 1985, Blanchard, 1984). The hypothesis of "time inconsistency" has also to be tested empirically. This might be realized by regarding the evidence of a systematic "inflation bias" in those countries where the central bank is less independent and more subservient to the government.

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Summary

The purpose of this paper is to give a non-technical review of the current issues in the international literature with regard to the game-theoretic approach in monetary policy. After the Lucas-Sargent-Wallace ineffectiveness hypothesis in the seventies a new policy-issue came about dealing with the time-inconsistency of policy makers. This question is closely related to the concepts of policy-credibility and reputation of central banks. According to the game-theoretic approach the interaction process between the strategic behaviour of the policymaker and the rational public will result in an endogenous monetary policy. This implies that a discretionary

policy has to be abandoned, because the long-run outcomes in terms of inflation and employment will be less beneficial (Nash-equilibrium) than in the case of a precommitment in monetary policy (rule).

Zusammenfassung

Dieser Artikel versucht eine nicht-technische Übersicht über in der internationalen Literatur diskutierte Anwendungen der Spieltheorie auf geldpolitische Fragestellungen zu geben (Debatte über regelgebundene versus diskretionäre Politik). Nach der Ineffektivitätshypothese von Lucas, Sargent und Wallace in den siebziger Jahren trat mit der Zeitinkonsistenz der Politik ein neues Politikproblem in den Vordergrund. Dieses Problem ist eng mit den Konzepten der Glaubwürdigkeit und Reputation von Zentralbanken verbunden. Der spieltheoretischen Analyse zufolge führt die Interaktion zwischen den strategisch handelnden politischen Akteuren und der rational agierenden Öffentlichkeit zu einer endogen determinierten Geldpolitik. Dies impliziert, daß man diskretionäre Politik aufgeben muß, weil ihre langfristigen Resultate bezüglich Inflation und Beschäftigung schlechter wären (Nash-Gleichgewicht) als die einer ex ante angekündigten Gledmengenregel.

Prof. Dr. Jac J. Sijben, Tilburg Universität, Katholieke Universiteit Brabant, Postbox 90153, NL-5000 Le Tilburg.

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